1-1-2011

Interpretations of embodied cognition

Shaun Gallagher
University of Central Florida

Interpretations of embodied cognition

Abstract

The concept of embodied cognition (EC) is not a settled one. A variety of theorists have attempted to outline different approaches and meanings related to this concept. They range from radical embodiment to minimal embodiment, and a number of positions in between. In addition, a variety of approaches to the study of cognition have been closely associated with the notion of embodiment – including enactive, embedded, and extended or distributed cognition approaches. Within these different perspectives there is no strong consensus on what weight to give to the concept of embodiment. Moreover, contrary to what some may think, not all EC approaches share a common opposition to the classical computational model of cognition. In this chapter I want to map out the landscape of these various senses of embodied cognition.

Keywords

interpretations, embodied, cognition

Disciplines

Arts and Humanities | Law

Publication Details

Gallagher, S. (2011). Interpretations of embodied cognition. In W. Tschacher and C. Bergomi (Eds.), The Implications of Embodiment: Cognition and Communication (pp. 59-70). United Kingdom: Imprint Academic.

Gallagher, S. (forthcoming). Interpretations of embodied cognition. In W. Tschacher and C. Bergomi (eds.), The Implications of Embodiment: Cognition and Communication. Exeter: Imprint Academic. (May 31)

Interpretations of embodied cognition[1]

Shaun Gallagher
Philosophy and Cognitive Sciences
Institute of Simulation and Training
University of Central Florida (USA)
Humanities Division
University of Hertfordshire (UK)
gallaghr@mail.ucf.edu

The concept of embodied cognition (EC) is not a settled one. A variety of theorists have attempted to outline different approaches and meanings related to this concept. They range from radical embodiment to minimal embodiment, and a number of positions in between. In addition, a variety of approaches to the study of cognition have been closely associated with the notion of embodiment – including enactive, embedded, and extended or distributed cognition approaches. Within these different perspectives there is no strong consensus on what weight to give to the concept of embodiment. Moreover, contrary to what some may think, not all EC approaches share a common opposition to the classical computational model of cognition. In this chapter I want to map out the landscape of these various senses of embodied cognition.

Minimal embodiment

One recent account of how embodiment figures into explanations of cognition takes social cognition as a focus. What Goldman and de Vignemont (2009) say about social cognition, however, can be applied to cognition generally. They place strict constraints on how we are to understand embodiment. So much so that most embodied theorists would likely fail to recognize what they describe as a case of embodied cognition and take it more as a dismissal of the importance of the body. Their starting point assumes that almost everything of importance for human cognition happens in the brain, "the seat of most, if not all, mental events" (2009, 154). Accordingly, the notion of embodied cognition seems all the more problematic if one defines the body as not including the brain, which is what they do: "Embodiment theorists want to elevate the importance of the body in explaining cognitive activities. What is meant by 'body' here? It ought to mean: the whole physical body minus the brain. Letting the brain qualify as part of the body would trivialize the claim that the body is crucial to mental life" (154). In addition to removing the brain from the body, G&D remove the body from the environment: they want to understand the contribution of "the body (understood literally), not [as it is

[1] My research on this project was supported by a CNRS research grant as Visiting Researcher, Centre de Recherche en Epistémelogie Appliquée, École Polytechnique, Paris (2009-2010).

related] to the situation or environment in which the body is embedded" (154). A core claim in EC, however, is that the body *cannot be uncoupled from its environment.*[2] It would be difficult to find any EC theory that defines the body as this "literal," and literally dead, brainless thing.

G&D further rule out anatomy and body activity (actions and postures) as trivial rather than important or constitutive contributors to cognitive processes. They are thus left with, as they put it, "sanitized" body representations. They regard the concept of body-formatted representations ("B-formats") as "the most promising" concept for promoting an EC approach (155). Unfortunately, they explain, there is no consensus about what B-formats are and their role in cognition is still under debate. It seems clear, however, that G&D consider B-formatted representations to be brain states (in the context of social cognition they involve mirror neuron activation [156]), and as such, they do what many theorists do: they reduce embodiment to a set of neuronal processes. Although it's not clear how the reduction of the body to a set of brain processes remains consistent with their earlier elimination of the brain as part of what embodiment means, this strategy really brings us back to a model that is not inconsistent with the classical computational (CC) one that EC opposes, or at the very lease it gives us an internalist view that is not inconsistent with the bodiless brain-in-a-vat conception of cognition.

G&D thus define embodiment and frame the problem in a way that precludes any significant contribution from the body. In doing so, they ignore the fact that EC challenges the very framework that they adopt. G&D nonetheless present a clear challenge to EC, and they make it specific by providing a list of questions that EC theorists should answer in order to clarify their claims, and to help those who are not quite sure. Here is their list (p. 158).

1. Which interpretation of embodiment do they have in mind?
2. Which sectors of cognition, or which cognitive tasks, do they say are embodied; and how fully does each task involve embodiment?
3. How does the empirical evidence support the specific embodiment claims under the selected interpretation(s)?
4. How do the proffered claims depart substantially from CC?

Since a number of versions of EC reject representationalist theories of cognition, we can add a fifth question, closely related to (4).

5. Do mental representations play a role in this version of EC?

We can use these questions to guide our topographical survey, and we can start by asking them of G&V's "most promising" but minimal conception of EC. (1) They suggest a minimal interpretation which frames embodiment in terms of sanitized brain processes. (2) Accordingly, they suggest it applies to some (but not all) aspects of social cognition, and not much else. As they say, "It is doubtful, however, that such a thesis can be generalized" (158). On their view, B-formatted representations (perhaps

[2] E.g., "Given that bodies and nervous systems co-evolve with their environments, and only the behavior of complete animals is subjected to selection, the need for … a tightly coupled perspective should not be surprising" (Beer, 2000). Also see Brooks (1991); Chemero (2009), Chiel and Beer (1997).

mirror neuron activation) may feed a cognitive simulation process. (3) The empirical evidence is tied to MN research, and evidence that lesions that affect B-formatted representations "interfere with action and emotion recognition" (p. 156). (4) Although this minimal version of EC seems relatively consistent with CC, since social cognition is not "pervasively embodied," G&V suggest that CC never anticipated the "low-level nature" of B-representations. (5) This version of EC is strongly representational.

Biological embodiment: anatomy, chemistry, and movement

In contrast to G&D, who rule out anatomy and bodily movement as important, non-trivial factors for cognition, other theorists suggest that anatomy and movement are important contributors to the shaping of cognition prior to brain processing (pre-processing) and subsequent to brain processing (post-processing) of information in the cognitive system (e.g., Chiel and Beer 1997; Shapiro 2004; Straus 1966; see Gallagher 2005a). Embodiment in this case means that extra-neural structural features of the body shape our cognitive experience. For example, the fact that we have two eyes, positioned as they are, delivers binocular vision and allows us to see the relative depth of things. Similar things can be said about the position of our ears and our ability to tell the direction of sound. As Shapiro puts it, "the point is not simply [or trivially] that perceptual processes fit bodily structure. Perceptual processes *depend on and include* bodily structures" (2004, 190).

Our sensory experience also depends on the way our head and body move, as we see in the case of parallax (Churchland, Ramachandran and Sejnowski 1994; Shapiro 2004). Furthermore, our motor responses, rather than fully determined at brain-level, are mediated by the design of muscles and tendons, their degrees of flexibility, their geometric relationships to other muscles and joints, and their prior history of activation (Zajac 1993). Movement is not always centrally planned; it is based on a competitive system that requires what Andy Clark terms 'soft assembly'. The nervous system learns 'to modulate parameters (such as stiffness [of limb or joint]) which will then *interact* with intrinsic bodily and environmental constraints so as to yield desired outcomes' (Clark 1997: 45).

Many of these insights are still cast in terms of information processing, and as such may be consistent with the general principles of classical cognitivism. As Shapiro notes: "steps in a cognitive process that a traditionalist would attribute to symbol manipulation might, from the perspective of EC, emerge from the physical attributes of the body" (2007, p. 340). In addition, even if the body is doing some of the work, cognitivists could easily claim that pre-processing is in fact feeding the more central processing that is certainly more constitutive of cognition, just as post-processing is to some degree determined by instructions from the brain as central processor.

More holistic, proprioceptive and emotion-related processes, however, may be more challenging to the classical conception. There is good empirical evidence that they have a profound effect on perception and thinking. For example, vibration-induced proprioceptive patterns that change the posture of the whole body are interpreted as changes in the perceived environment (Roll and Roll 1988: 162). Proprioceptive adjustments of the body schema can help to resolve perceptual conflicts (Harris 1965:

419; Rock and Harris 1967). Experimental alterations of the postural schema lead to alterations in space perception and perceptual shifts in external vertical and horizontal planes (Bauermeister 1964; Wapner and Werner 1965). Likewise hormonal changes – changes in body chemistry – as well as visceral and musculoskeletal processes, can bias perception, memory, attention, and decision-making (Damasio 1994; Bechara et al. 1997; Gallagher 2005; Shapiro 2004). The regulation of body chemistry is not autonomous from cognitive processes, and vice versa. "Body regulation, survival, and mind are intimately interwoven" (Damasio, 1994, p. 123).

On this reading of EC, the classic computational/functionalist thought experiment of the brain-in-the-vat completely fails. The claim that cognitive function and experience would be the same, or even similar to a fully embodied subject, if the appropriate inputs were delivered to a disembodied brain in a vat fails to take into consideration the contributions of body performances. As pointed out by a number of theorists, the experimenters would have to replicate everything that the biological body delivers in terms of pre-and post-processing, hormonal and neurotransmitter chemistry, and emotional life. Thus, as Damasio suggests, this would require the creation of a body surrogate "and thus confirm that 'body-type inputs' are required for a normally minded brain after all" (1994, p. 228; also see Gallagher 2005b; Cosmelli and Thompson 2007).

The body as semantic engine

Not only does the structure, composition, and motor abilities of the body determine how we experience things, they also determine what we experience, and how we understand the world. Varioius experiments show that how we are moving or posturing ourselves (e.g., pushing away vs. pulling toward) will affect our evaluations of target objects (e.g., Cacioppo, Priester & Bernston 1993; Chen & Bargh 1999). Shapiro builds on observations made by French (1990) about the kind of cognitive associations we might make if our bodies were different. If our eyes were located on our knees, for example, it would not only change our spatial perspectives, it would create differences in our conceptual associations. We might associate crawling on the floor with torture (Shapiro 2004, 195).

Lakoff and Johnson, drawing primarily on cognitive and experimental linguistics and cultural anthropology, but also citing psychological, neuroscientific, and cognitive science research on mental rotation, mental imagery, gestures, and sign language, have famously argued that our conceptual life begins in spatial and motor behaviors and derives meaning from bodily experience (Johnson 2010; Lakoff, in press). Accordingly, the "peculiar nature of our bodies shapes our very possibilities for conceptualization and categorization" (Lakoff and Johnson 1999, p. 19). For them, the specific mechanism that bridges embodied experience and conceptual thought is metaphor.

Metaphors are built on basic and recurring image-schemas such as front-back, in-out, near-far, pushing, pulling, supporting, balance, etc., and the basic image-schemas are built on bodily experience (1999, p. 36). Thus, "the concepts of *front* and *back* are body-based. They make sense only for beings with fronts and back. If all beings on this planet were uniform stationary spheres floating in some medium and perceiving equally in all directions, they would have no concepts of *front* and *back*" (1999, p. 34). Similar things can be said for *up-down*, and so forth. These basic image-schemas then shape, metaphorically, our abstract conceptual thought in relation to planning and decision-making, for example. Thus, justice is conceived in terms of balance; virtue is conceived in terms of being upright; planning for the future is conceived in terms of up and forward – "What's up?" "What's coming up this week?" The *in* and *out* body-schema, and the containment metaphor, for example, range over a vast set of metaphors and concepts, from the close to literal: 'John went out of the room', to the abstract: 'She finally came out of her depression', or 'I don't want to leave any relevant data out of my argument', to the logically abstract, such as the law of the excluded middle in logic (Johnson 1987). This view has been extended to explanations of mathematical concepts as well (Lakoff and Núñez 2000).

At least in some respects, the embodied view taken up by Lakoff and Johnson involves neural embodiment. "An embodied concept is a neural structure that is part of, or makes use of the sensorimotor system of our brains. Much of conceptual inference is, therefore, sensorimotor inference" (1999, p. 20). Although generally the Lakoff-Johnson view is taken to be consistent with a connectionist view, on at least one interpretation (Zlatev 2010) their position is not inconsistent with classical cognitivism. Yet, consistent with more enactive views of cognition, they eschew strong representationalism.

> As we said in *Philosophy in the Flesh*, the only workable theory of representations is one in which a representation is a flexible pattern of organism-environment interactions, and not some inner mental entity that somehow gets hooked up with parts of the external world by a strange relation called 'reference'. We reject such classical notions of representation, along with the views of meaning and reference that are built on then. Representation is a term that we try carefully to avoid. (Johnson & Lakoff 2002: 249-250)

Embodied functionalism

In some regards the notion of an embodied functionalism is either trite, since even functionalist systems need to be physically embodied, or contradictory, since one hallmark of functionalism is a certain indifference to the physicality that sustains the system (body neutrality, multiple realizability). The idea that functionalists should take notions of embodiment seriously, however, can be found in some discussions of the extended mind, e.g., Andy Clark (2008a), Wheeler (2005); Rowlands (2006; 2010). I'll focus on Clark as the main proponent of this view. On the one hand, Clark argues for a step back towards the idea of a minimal embodiment in the sense that he considers factors associated with anatomical determination and embodied semantics to be "trivial and uninteresting" rather than deeply "special" (2008b, 38). On the other hand, he defends the notion that the body plays an important role as part of the extended mechanisms of cognition. In this regard, the physical body functions as a non-neural vehicle for cognitive processes, in much the same general way that the physical processes of neurons do. The body is part of an extended cognitive system that starts with the brain and includes body and environment. As he puts it, "the larger systemic wholes, incorporating brains, bodies, the motion of sense organs, and (under some conditions) the information-bearing states of non-biological props and aids, may sometimes constitute the *mechanistic supervenience base* for mental states and processes" (2008b, 38).

This view is not to be confused with the idea that the (human) body offers certain determining constraints (sensory-motor contingencies) that make (human) experience unique, an idea associated with O'Regan and Noë's (2001) theory of enactive perception. Clark is not convinced that an animal with a very different body could not experience certain aspect of the spatial environment in exactly the same way. Rather, different bodies can compute or process information differently but still produce the same experience. The important thing for Clark (citing as evidence experiments by Ballard et al. 1997) is that part of the computing mechanism can include the body. In accomplishing certain tasks, for example, we could store task-relevant information in our brain-based memory system and consult the information in that store; alternatively, we could leave it the information in the environment where it is and simply use our bodies to perceptually consult it when needed. In the latter case, consistent with Rob Wilson's (1994) notion of 'exploitative representation' and 'wide computing', the perceiving body is playing a certain computational role that could be done fully "in the head"; the body does this sort of thing frequently, and in effect operates as an "external" vehicle for cognition. As Clark (2007) makes clear, this view of an embodied extension of cognition (he calls it 'simple embodiment' [Clark 1999]) is also consistent with a robust representationalism for higher cognitive processes, as well as with a minimal representationalism (involving action-oriented representations) for action (see Clark and Grush 1999).

One way to split the difference between those who would argue for a special and essential role for embodiment and those who would give the body only a "simple" functional role, is to suggest that embodiment especially matters for phenomenal consciousness, but not for cognition. The same cognitive results supervening on specifically embodied processes may feel different or register differently in experience, while still being functionally equivalent in regard to cognitive state.

Clark hesitates to accept this kind of division of labor. He argues that even for experience one should allow the possibility that the cognitive system will provide "compensatory downstream adjustments" that would, so to speak, even out differences in the experiential aspects that accompany cognition (Clark 2007). While there seems no strong reason to think this is the case (Clark cites no evidence to support this view), or even to think that it should be the case (after all, why should it matter that a frog's consciousness have the same phenomenal feel as a human's consciousness), there is some evidence against it. Wearing prism goggles changes visual experience by altering the angle of perspective on the visual field. A set of prism goggles may shift the visual field to the right by 40 degrees, or may even invert the visual field. It was once thought that the perceptual system eventually corrects for this distortion and the subject, who is initially disoriented, starts to experience the world and act in it as if she were not wearing the goggles. That would mean that the visual system makes compensatory downstream adjustments at brain level to restore visual-motor experience to our normal parameters. But this has been shown not to be the case (Linden et al. 1999). Subjects make important adjustments in their motor behavior, but their visual experience remains distorted. Prism glasses basically change the normal visual system at the basic bodily level (that is, the normal workings of the physical eye, plus the prism glasses, would be equivalent to a different eye structure). Brain-based processes that may allow us to adjust motor behavior to cope with this different visual experience, however, do not allow for a compensatory downstream adjustments that would restore upright visual experience. Even if this suggests that Clark might be wrong about the idea of compensatory effects with respect to experience, restoring the compromise division of labor (functionalist cognition vs embodied consciousness) it was meant to challenge, is hardly consistent with stronger versions of EC.

Radical embodiment

Enactive views on embodied cognition emphasize the idea that perception is *for action*, and that this action-orientation shapes most cognitive processes. This approach often comes with strong calls to radically change our ways of thinking about the mind and doing cognitive science (e.g., Gallagher and Varela 2003; Thompson 2007; Thompson and Varela 2001; Varela, Thompson, and Rosch 2001). Thompson and Varela (2001) agree on Clark's (1999) three-point summary of the enactive view:

(1) understanding the complex interplay of brain, body and world requires the tools and methods of nonlinear dynamical systems theory;
(2) traditional notions of representation and computation are inadequate;
(3) traditional decompositions of the cognitive system into inner functional subsystems or modules ('boxology') are misleading, and blind us to arguably better decompositions into dynamical systems that cut across the brain–body–world divisions.

(Thompson and Varela 2001, 418; also see Chemero 2009, 29).

Similar to Clark and the idea of extended cognition, enactive approaches argue that cognition is not entirely "in the head," but distributed across brain, body, and environment. In contrast to Clarke's functionalist view, however, enactive theorists claim that the (human) bodily processes shape and contribute to the constitution of consciousness and cognition in an irreducible and irreplaceable way. Specifically, on the enactive view, biological aspects of bodily life, including organismic and emotion regulation of the entire body, have a permeating effect on cognition, as do processes of sensori-motor coupling between organism and environment. Noë (2004; also see O'Regan and Noë 2001; Hurley 1998) developed a detailed account of enactive perception where sensory-motor contingencies and environmental affordances take over the work that had been attributed to neural computations and mental representations.

Thompson and Varela (2001) and Gallagher (2001; 2005a) add to this the dimension of intersubjective interaction, which, they regard, in contrast to Goldman and de Vignemont, as involving fully embodied processes that involve facial expression, posture, movement, gestures, and distinct forms of sensory-motor couplings. This is supported by developmental studies that suggest infants engage in embodied intersubjective practices from birth. Mirror neurons may contribute to "primary intersubjecive" processes (Trevarthen 1979), understood as part of the neural underpinnings of enactive social perception of motor intentions and response preparation rather than a simulation or simple mirroring of mental states (Gallagher 2007). Context and social environment also contribute to "secondary intersubjective" (Trevarthen and Hubley 1978) practices starting at 9-12 months of age. In the intersubjective context, perception is often *for inter-action* with others, where perceptually-guided interaction becomes a principle of social cognition and generates meaning in a process of 'participatory sense-making' (De Jaegher and Di Paulo 2007; De Jaegher, Di Paulo, and Gallagher, in press; Gallagher 2009).

Table 1. Different theories of embodiment

Interpretation	*Minimal embodiment*	*Embodied functionalism*	*Biological embodiment*	*Embodied semantics*	*Radical (enactive) embodiment*
Sectors of cognition	Social cognition	Perception/action & higher-level cognition	Perception/ action	Higher-level cognition	Perception/ action, social cognition
Empirical evidence	Neuroscience (MNs, lesions)	Experimental psychology, robotics, engineering	Biology, experimental psychology	Linguistics, psychology, neuroscience, cultural anthropology	Developmental psychology, neuroscience, empirical psychology
Consistent with CC	Yes	Yes	Neutral	Neutral	No
Representations	Strong yes	Yes for "representation hungry" processes and minimal representations for action	Weak	Weak	No
Representatives	Goldman & De Vignemont	Clark, Wheeler, Rowlands	Shapiro, Beers	Johnson, Lakoff, Nuñez,	Varela, Thompson, Noë, Gallagher, Hutto

Conclusion

It is often thought that EC approaches, even if they differ among themselves, are united in their opposition to traditional versions of computationalism and representationalism, but this is clearly not the case. Indeed, disagreements within the EC camp are primarily disagreements about just these issues. But perhaps one important outcome of the EC approaches is that they have moved the issues about computationalism and representationalism front and center, even in the minds of those who have taken less-embodied approaches. Thus there have been recent wholesale investigations into the concept of representation (e.g., Chemero 2009; Hutto 2008; Gallagher 2008; Ramsey 2007), as well as careful and somewhat defensive explanations of what representation means in analytic philosophy of mind (e.g., Burge 2010; and see Crane 2008 for a similar analysis). On the EC side, it seems incumbent to deliver on some promissory notes. As Chemero (2009) makes clear, it will be important to "scale up" dynamic systems approaches from the analysis of action and perception to higher cognitive performance in what are considered to be "representation-hungry" tasks (Clark and Toribio 1994). "It is still an open-question how far beyond minimally cognitive behaviors radical embodied cognitive science can get" (Chemero 2009, 43). Accordingly, within EC one of the most important and interesting debates is that between functionalist and radical versions, the first appealing to representations and eschewing any essentialist view of the body, the second dismissing representations and insisting on the ineliminable nature of the body. One of the leading theoretical questions in this field is whether it's possible to integrate these views (see Menary 2007) or to defend a non-functionalist and enactive version of the extended mind hypothesis (Gallagher, in press).

What is clear, however, in contrast to Goldman and de Vignemont's critical suggestions, is that embodied approaches to cognition are not brainless; the proper explanatory unit is brain-body-environment rather than the "body (understood literally)." Furthermore, EC is supported by good scientific evidence from a variety of disciplines, including brain science. Understood broadly, EC is also able to address multiple sectors of cognition, from action and perception, to social cognition, and more abstract, higher-level cognition. Goldman and de Vignemont (2009) begin their essay dramatically by suggesting that "a specter is haunting the laboratories of cognitive science" – the EC reply can only be "*Bodies of the world unite ... with your brains and your environments!"*

References

Ballard, D. H., Hayhoe, M. M., Pook, P. K. and Rao, R. P. N. 1997. Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences* 20 (4): 723-67.

Bauermeister, M. 1964. The effect of body tilt on apparent verticality, apparent body position and their relation. *Journal of Experimental Psychology,* 67: 142-147.

Bechara, A., Damasio, H., Tranel, D. and. Damasio, A. R. 1997. Deciding advantageously before knowing the advantageous strategy. *Science* 275 (5304): 1293 – 1295.

Beer, R. 2000. Dynamical approaches to cognitive science. *Trends in Cognitive Sciences* 4: 91-99.

Brooks, R. 1991. Intelligence without representation. *Artificial Intelligence* 47:139-59.

Burge, T. 2010. Origins of perception. Paper presented as the *First 2010 Jean Nicod Prize Lecture*. Paris 14 June 2010.

Cacioppo, J. T., Priester, J. R., & Bernston, G. G. 1993. Rudimentary determination of attitudes: II. Arm flexion and extension have differential effects on attitudes. *Journal of Personality and Social Psychology* 65: 5-17.

Chen, S., & Bargh, J. A. 1999. Consequences of automatic evaluation: Immediate behavior predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin* 25: 215-224.

Chemero, A. 2009. *Radical Embodied Cognitive Science*. Cambridge, MA: MIT Press.

Chiel, H. and R. Beer. 1997. The brain has a body: Adaptive behavior emerges from interactions of nervous system, body and environment. *Trends in Neuroscience* 20 (1997): 553–57.

Cosmelli, D. and Thompson, E. 2007. Embodiment or envatment? Reflections on the bodily basis of consciousness. In J. Stewart, O. Gapenne, and E. di Paolo (eds.), *Enaction: Towards a New Paradigm for Cognitive Science*. Cambridge, MA: MIT Press.
Churchland, P. S. Ramachandran, V. S. and Sejnowski, T. J. 1994. A critique of pure vision. In C. Koch and J. L. Davis (eds.), *Large-scale Neuronal Theories of the Brain*. Cambridge, MA: MIT Press.
Clark, A. 2008a. *Supersizing the Mind: Reflections on Embodiment, Action, and Cognitive Extension.* Oxford: Oxford University Press.
Clark, A. 2008b. Pressing the flesh: A tension on the study of the embodied, embedded mind. *Philosophy and Phenomenological Research* 76: 37–59.
Clark, A. 1999. An embodied cognitive science? *Trends in Cognitive Sciences* 3 (9): 345-51.
Clark, A. 1997. *Being There*. Cambridge, MA: MIT Press.
Clark, A. and Grush, R. 1999. Towards a cognitive robotics. *Adaptive Behavior* 7 (1): 5-16.
Clark, A. and Toribio, J. 1994. Doing without representing? *Synthese* 101: 401-431.
Crane, T. 2008. Is perception a propositional attitude? *Philosophical Quarterly* doi: 10.1111/j.1467-9213.2008.608.x
Damasio, A. 1994. *Descartes Error: Emotion, Reason, and the Human Brain.* New York: G. P. Putnam.
De Jaegher, H., and Di Paolo, E. 2007. Participatory Sense-Making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences* 6, 485-507
De Jaegher, H. Di Paulo, E. and Gallagher, S. In press. Can social interaction constitute social cognition? *Trends in Cognitive Sciences*.
French, R. 1990. Subcognition and the limits of the Turing test. *Mind* 99: 53–65.
Gallagher, S. (in press). The overextended mind. *Versus: Quaderni di studi semiotici*.
Gallagher, S. 2009 Two problems of intersubjectivity. *Journal of Consciousness Studies* 16, 298-308
Gallagher, S. 2008. Are minimal representations still representations? *International Journal of Philosophical Studies* 16 (3): 351-69.
Gallagher, S. 2007. Simulation trouble. *Social Neuroscience.* 2 (3-4): 353-65.
Gallagher, S. 2005a. *How the Body Shapes the Mind*. Oxford: Oxford University Press.
Gallagher, S. 2005b. Metzinger's matrix: Living the virtual life with a real body. *Psyche: An interdisciplinary journal of research on consciousnesss.* (http://psyche.cs.monash.edu.au/symposia/metzinger/Gallagher.pdf)
Gallagher, S. 2001. The practice of mind: Theory, simulation, or interaction? *Journal of Consciousness Studies*, 8 (5–7): 83–107
Gallagher, S. and Francisco Varela. 2003. Redrawing the map and resetting the time: Phenomenology and the cognitive sciences. *Canadian Journal of Philosophy*. Supplementary Volume 29: 93-132.
Goldman, A. and De Vignemont, F. 2009. Is social cognition embodied? *Trends in Cognitive Sciences* 13 (4): 154-59.
Harris, C. S. 1965. Perceptual adaptation to inverted, reversed, and displaced vision. *Psychological Review,* 72: 419-444.

Hurley, S. (1998) Consciousness in Action, Harvard University Press.
Hutto, D. 2008. *Folk Psychological Narratives The Sociocultural Basis of Understanding Reasons*. Cambridge, MA: MIT Press.
Johnson, M. 2010. Metaphors and cognition. In S. Gallagher and M. Schmicking (eds.), *Handbook of Phenomenology and Cognitive Science*. Dordrecht: Springer.
Johnson, M. 1987. *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason*. Chicago: University of Chicago Press.
Johnson, M. and Lakoff, G. 2002. Why cognitive linguistics requires embodied realism. *Cognitive Linguistics* 13 (3): 245-63.
Lakoff, G. In press. The Neural Theory of Metaphor. In R. Gibbs (ed.), *The Cambridge Handbook of Metaphor and Thought.* Cambridge: Cambridge University Press.
Lakoff, G. and Johnson, M. 1999. *Philosophy in the Flesh: The Embodied Mind and its Challenge to Western Thought*. New York: Basic Books.
Lakoff, G. and Rafael Núñez, 2000, *Where Mathematics Comes From*. New York: Basic Books.
Linden, D. E. J., Kallenbach, U., Heineckeô, A. Singer, W. and Goebel, R. 1999. The myth of upright vision. A psychophysical and functional imaging study of adaptation to inverting spectacles. *Perception* 28: 469-81.
Menary, R. 2007. *Cognitive Integration: Mind and Cognition Unbounded*. Basingstoke: Palgrave Macmillan.
Noë, A. 2004. *Action in Perception*. Cambridge, MA: MIT Press.
O'Regan, K. and Noë, A. 2001. A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences* 23: 939–973.
Ramsay, W. 2007. *Representation Reconsidered.* Cambridge: Cambridge University Press.
Rock, I. and Harris, C. S. 1967. Vision and touch. *Scientific American*, 216 (5): 96-104.
Rowlands, M. 2010. *The New Science of the Mind*. Cambridge, MA: MIT Press.
Rowlands, M. 2006. *Body Language,* Cambridge, MA: MIT Press.
Roll, J-P. and Roll, R.. 1988. From eye to foot: A proprioceptive chain involved in postural control. In G. Amblard, A. Berthoz, and F. Clarac (eds.), *Posture and Gait: Development, Adaptation, and Modulation* (pp. 155-164). Amsterdam: Excerpta Medica.
Wapner, S. and Werner, H. 1965. An experimental approach to body perception from the organismic developmental point of view. In S. Wapner and H. Werner (eds.), *The Body Percept*. New York: Random House.
Shapiro, L. A. 2004. *The Mind Incarnate.* Cambridge, MA: MIT Press.
Shapiro, L. A. 2007. The embodied cognition research programme. *Philosophy Compass* 2/2 (2007): 338–346, 10.1111/j.1747-9991.2007.00064.x
Straus, E. 1966. *Philosophical Psychology.* New York: Basic Books.
Thompson, E. 2007. *Mind in Life: Biology, Phenomenology and the Sciences of Mind,* Cambridge, MA: Harvard University Press.
Thompson, E. and Varelam F. 2001. Radical embodiment: Neural dynamics and consciousness. *Trends in Cognitive Sciences* 5 (10): 418-25
Trevarthen, C. B. 1979. Communication and cooperation in early infancy: A description of primary intersubjectivity. In M. Bullowa (ed.), *Before Speech*. Cambridge: Cambridge University Press.

Trevarthen, C. and Hubley, P. 1978. Secondary intersubjectivity: Confidence, confiding and acts of meaning in the first year. In A. Lock (ed.), *Action, Gesture and Symbol: The Emergence of Language* (pp. 183-229). London: Academic Press.
Varela, F. J., Thompson, E. and Rosch, E. 1991. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: MIT Press.
Wilson, R. A. 1994. Wide computationalism. *Mind* 103: 351-72.
Wheeler, M. 2005. *Reconstructing the Cognitive World.* Cambridge, MA: MIT Press.
Zajac, F. E. 1993. Muscle coordination of movement: A perspective. *Journal of Biomechanics* 26, suppl 1: 109-124.
Zlatev, J. 2010. Phenomenology and Cognitive Linguistics. In S. Gallagher and D. Schmicking (eds.), *Handbook of Phenomenology and Cognitive Science*. Dordrecht: Springer.